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(54) IMPROVEMENTS IN PISTONS

(71) We, WELLWORTHY LIMITED, a British company of Lymington, Hampshire, SO4 9YE, England, do hereby declare this invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to pistons for combustion engines, and in particular to pistons for indirect injection, compression ignition, internal combustion engines.

In indirect injection compression ignition engines, combustion occurs in a combustion chamber communicating with the space above the piston crown through a narrow passage or "throat". During operation, the hot gases of combustion emerging from the throat impinge on the surface of the piston crown, producing increased heating of the crown in the zone of impingement. In order to resist this localised heating, particularly when the piston is made of a material, such as an aluminium alloy, which is prone to thermal attack and would be eroded by this localised heating, it is known to insert a plug of a heat-resistant material, such as austenitic steel, into the piston crown in the said zone of impingement. The plug is formed with a stem which extends through the crown, and the plug is held in place by a nut threaded onto the stem beneath the crown. The plug is provided with a conical undersurface which is clamped against a corresponding conical seating in the crown to provide a gas-tight seal between the plug and crown.

In operation, the heat-resistant plug is heated to very high temperatures by the combustion gases, and it has frequently been found that the conical seating in the crown which contacts the hot plug suffers surface cracking due to this very high temperature.

It is an object of the present invention to provide a piston construction which overcomes this problem.

According to the present invention there is provided a piston for a combustion engine, formed from a light metal alloy, and having a crown provided with a surface, a zone of which, in normal operation of the piston, is heated to a temperature which, if the zone were to be formed by the basic piston alloy, would result in thermal attack of the basic alloy, a member formed from a material resistant to attack at said temperature being secured to the crown in said zone so as to form a continuation of the crown surface, wherein an intermediate element is disposed between the member and the basic alloy of the crown and forms a continuation of the crown surface adjacent the continuation formed by the member, said element having a thermal strength greater than that of the basic alloy, and, in normal operation, being effective to limit heat flow from the member to the basic alloy of the crown to a level which avoids, or substantially avoids, thermal cracking of the basic alloy adjacent said element.

The invention also consists in a combustion engine, particularly an indirect injection, compression ignition, internal combustion engine, fitted with one or more piston as just defined.

The intermediate element serves to reduce the heat which is transferred from the member to the basic alloy of the crown during normal operation to a level which eliminates, or reduces to insignificant proportions, thermal cracking of the basic alloy in the region of the member. Since the intermediate element also forms a continuation of the crown surface directly adjacent, for example surrounding, the member, the surface of the crown formed by the basic alloy of the piston is further removed from said zone. Furthermore, due to the thermal strength of the material of the intermediate element, the element is not itself liable to thermal cracking.

The intermediate element may comprise an insert of heat-resistant material possessing a thermal conductivity lower than that of the basic piston alloy, positioned within a recess in the exposed

surface of the crown, and provided with a seating on which the member, which comprises a plug, seats. The plug may have a stem which extends through the insert and crown, a nut being threaded onto the end of the stem beneath the crown to retain the plug, insert and crown firmly clamped together with the insert in gas-sealing relationship with the plug and crown.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:—

Figures 1, 2 and 3 are diagrammatic, fragmentary cross-sections through the crown of an indirect injection, diesel engine piston, according to different embodiments of the invention.

Referring to the drawings, each Figure shows a portion of a piston crown 1 having an upper surface 2 which, in operation of the piston is exposed to the hot gases of combustion. The piston, including the crown 1, is basically formed, for example cast, from a light metal alloy such as an aluminium alloy. The piston is intended for use in an indirect injection diesel engine, in which combustion occurs in a combustion chamber (not shown) communicating, via a narrow passage or throat (not shown), with the space above the exposed surface 2 of the crown 1. In such an engine, the concentrated jet of hot gases of combustion emerging from the combustion chamber throat impinges on the surface 2 and would, if the surface 2 in the zone of impingement were to be formed of the basic piston alloy, produce localised heating of this zone to such an extent that thermal erosion of the basic alloy in this zone would occur.

In each of the embodiments of the invention shown in the drawings, the crown 1, in the said zone, is formed with a recess 3 in which is seated an intermediate heat-resistant element in the form of an insert 4, the upper surface of which constitutes or defines a circular continuation or part of the crown surface. The insert 4 is formed with a conical seating 5 which, except for an annular relief 5a at its lower extremity, cooperates with the conical underside 6 of a heat-resistant plug 7. The plug 7 is provided with an integral stem 8, extending downwardly through a passage 9 in the insert 4 and crown 1, and is threaded at its lower end to receive a nut 10 by means of which the assembly comprising the insert 4 and plug 7 is secured to and within the crown. The cooperating surfaces of the recess 3 and insert 4, and the cooperating conical surfaces of the plug 7 and insert 4, are clamped tightly together by the nut 10, to form a gas-tight joint preventing leakage of combustion gases downwardly through the crown along the passage 9.

Due to the thickness of the insert 4, the upper or exposed edge or surface of the insert forms an annular continuation or part of the crown surface surrounding the circular continuation or part thereof formed by the upper surface of the plug 7. Thus, the joint face between the basic piston alloy and insert is, at the crown surface, spaced by a significant distance from the joint face between the plug and insert.

In the embodiments shown in Figures 2 and 3, the inserts 4 and recesses 3 are of frusto-conical profile. In particular, in Figure 2 the frusto-conical surfaces extend substantially the entire distance from the crown surface 2 to the passage 9, whereas, in Figure 3, the lower extremities of the frusto-conical surfaces are spaced radially of the passage 9, and the recess and plug each have a flat radially extending base.

As previously mentioned, in prior pistons in which the heat-resistant plug seats directly on the basic alloy of the crown, due to the high temperature to which the plug is heated by the combustion gases, the basic alloy suffers surface cracking in the region where the plug seats, due to this very high temperature. One purpose of the insert 4 is to control or restrict the heat flow from the plug to the seating of the recess 3 in the basic to a level which is acceptable to, and eliminates or reduces to insignificant proportions, this cracking of the basic alloy, without causing the plug temperature to rise beyond the heat-resistance capability of the plug material. For this purpose,the insert is made from a material which has a greater strength, at the high temperatures reached in normal engine operation, and a lower thermal conductivity, than the normal piston alloys.

The size and/or location of the zone of impingement of the concentrated jet of hot gases on the crown surface 2 is only approximate, and, furthermore, some of the gas in the jet may be deflected from the zone. Thus, a part of the concentrated jet may impinge on the crown surface 2 to the side of the plug. In prior pistons, this part of the jet will impinge directly on the basic piston alloy, causing direct heating thereof and resultant thermal attack. Another purpose of the insert is to minimise the risk of such thermal attack of the crown surface around the plug, without increasing the area of the upper surface of the head of the plug, and this is achieved by the previously mentioned annular upper edge or surface of the insert surrounding the head of the plug, on which said part of the jet will impinge, and which ensures that the joint face with the basic piston alloy is entirely remote from the area or zone directly impinged

upon and heated by at least the most damaging parts of the jet.

Suitable materials for the insert are sintered materials comprising aluminium with iron, manganese and/or cobalt, for example, aluminium with approximately 7% to 10% of iron, or aluminium with approximately 10% of manganese or cobalt, the percentages being by weight. Alternatively, cast or wrought alloys may be employed for the insert material, for example aluminium alloys incorporating manganese, or iron, and/or cobalt. Such alloys may also incorporate copper, nickel and magnesium; one example which has been found to be satisfactory being an alloy of aluminium including, by weight, 1% manganese, 2% copper, 2% nickel and 0.7% magnesium.

If the insert 4 is required to have an even greater hot strength, stainless steel, either of the austenitic or ferritic creep-resisting type, may be employed. For still greater hot strength, cobalt or nickel alloys could be employed, and the use of titanium alloys is also envisaged. The use of ceramics, such as silicon nitride, is also anticipated, since in theory, silicon nitride, should be highly successful in resisting thermal cracking of the basic piston alloy, although, in practice, problems associated with the mechanical cracking of silicon nitride inserts due to the differential thermal expansion which occurs between silicone nitride and the basic alloy of the piston and/or the material of the plug, would have to be overcome.

Prior heat-resistant plugs have commonly been made from austenitic steel, and this may be an appropriate material for the plug 7 in relatively low temperature operating conditions. However, since the thermal conductivity of the material of the insert 4, particularly if the material is one of those mentioned in the previous paragraph, is considerably lower than that of the piston alloys employed, the operating temperature of the plug 7, and to a lesser extent, the temperature of the insert 4, will be considerably increased. For this reason, it may be necessary to make the plug 7 from a more heat-resistant material, such as a Nimonic alloy ("Nimonic" is a Registered Trade Mark).

If required, and if difficulty is experienced in obtaining gas-tight joints between the cooperating seating surface of the insert 4 and the plug 7 and/or recess 3, a sealing gasket or gaskets may be interposed therebetween. The gasket material, which will also have to be heat-resistant may, for example, by fibrous alumino silicate.

It will be understood that various modifications may be made without departing from the scope of the present invention as defined in the appended claims. For example, numerous materials other than those specifically mentioned may be employed for the plug, insert and/or piston. The shape or configuration of the plug and/or insert may be varied, the seating surfaces of the plug, insert, and/or piston crown may likewise take a variety of different configurations, and the plug and insert may be secured to the crown in ways other than that specifically illustrated. For example the stem may be omitted or replaced by other forms of anchorage, the plug and/or the insert may be embedded in the crown by casting the piston alloy thereagainst, or the plug and/or insert may be secured to each other and/or in place in the piston crown, by welding, such as friction welding.

Although the intermediate element is, in the illustrated embodiments, shown as a separate insert, it could alternatively comprise a coating built up, for example by plasma-arc spraying, on the plug and/or piston crown. Alternatively, the intermediate element could be formed by sintering against the plug and/or crown.

Although, in the embodiments illustrated, the plug serves to plug the passage 9, this is not essential, and the passage extending through the crown may be eliminated. Thus the plug may be replaced by other forms of heat-resistant members, such as a plate.

Although primarily intended for use in indirect injection diesel engines, the invention may be applied to pistons for other types of engines, where the degree of localised heating of the piston crown might otherwise tend to erode or otherwise thermally attack the basic material of the piston.

WHAT WE CLAIM IS:—

1. A piston for a combustion engine, formed from a light metal alloy,and having a crown provided with a surface, a zone of which, in normal operation of the piston, is heated to a temperature which, if the zone were to be formed by the basic piston alloy, would result in thermal attack of the basic alloy, a member formed from a material resistant to said temperature being secured to the crown in said zone so as to form a continuation of the crown surface, wherein an intermediate element is disposed between the member and the basic alloy of the crown and forms a continuation of the crown surface adjacent the continuation formed by the member, said element having a thermal strength greater than that of the basic alloy, and, in normal operation, being effective to limit heat flow from the member to the basic alloy of the crown to a level which avoids, or substantially avoids,

thermal cracking of the basic alloy adjacent said element.

2. A piston as claimed in claim 1, wherein the intermediate element comprises an insert of heat-resistant material, possessing a thermal conductivity lower than that of the basic piston alloy, positioned within a recess in the surface formed by the alloy of the crown, and provided with a seating on which the member seats.

3. A piston as claimed in claim 2, wherein the member comprises a plug having a stem which extends through the insert and into the alloy of the crown to retain the plug, insert and crown firmly clamped together with the insert in gas sealing relationship with the plug and crown.

4. As piston as claimed in claim 3, wherein the plug stem extends through the crown, and retaining means is provided at the end of the stem beneath the crown to retain the plug, insert and crown clamped together.

5. A piston as claimed in any of claims 2 to 4, wherein the recess and insert are provided with frusto-conical cooperating side surfaces.

6. A piston as claimed in any of claims 2 to 5, wherein the insert is formed with a recess defining said seating for the member, the cooperating side surfaces of the member and seating recess being frusto-conical.

7. A piston as claimed in any preceding claim, wherein the intermediate element is formed from, or includes, a sintered material comprising aluminium with iron, manganese, and/or cobalt.

8. A piston as claimed in claim 7, wherein the sintered material comprises aluminium with approximately 7 to 10% by weight of iron, or with approximately 10% by weight of manganese or cobalt.

9. A piston as claimed in any of claims 1 to 6, wherein the intermediate element is formed from, or includes, a cast or wrought aluminium alloy.

10. A piston as claimed in claim 9, wherein the alloy incorporates manganese, iron and/or cobalt.

11. A piston as claimed in claim 10, wherein the alloy also incorporates copper, nickel and/or magnesium.

12. A piston as claimed in claim 11, wherein the alloy includes, by weight, approximately 1% manganese, 2% copper, 2% nickel, and 0.7% magnesium.

13. A piston as claimed in any of claims 1 to 6, wherein the intermediate element is formed from, or includes, austenitic or ferritic creep-resisting stainless steel.

14. A piston as claimed in any of claims 1 to 6, wherein the intermediate element is formed from, or includes, an alloy of cobalt, nickel, or titanium.

15. A piston as claimed in any of claims 1 to 6, wherein the intermediate element is formed from, or includes, a ceramic.

16. A piston as claimed in any preceding claim, wherein the heat-resistant member is formed from austenitic steel.

17. A piston as claimed in any of claims 1 to 15, wherein the heat-resistant member is formed from a Nimonic (Registered Trade Mark) alloy.

18. A piston as claimed in any preceding claim, including a heat-resistant sealing gasket between the member and intermediate element, and/or between the intermediate element and the alloy of the piston crown.

19. A piston as claimed in claim 18, wherein the gasket is formed from, or includes, fibrous alumino silicate.

20. A piston as claimed in claim 1, wherein the intermediate element comprises a coating or layer built up on the heat-resistant member and/or the alloy of the piston crown.

21. A light metal piston for a combustion engine, having a crown provided with a heat-resistant member and intermediate element substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

22. A light metal piston for a combustion engine, having a crown provided with a heat-resistant member and intermediate element substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

23. A light metal piston for a combustion engine, having a crown provided with a heat-resistant member and intermediate element substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.

24. A combustion engine provided with one or more pistons as claimed in any preceding claim.

25. A combustion engine as claimed in claim 24, an comprising an indirect injection, compression ignition, combustion engine.

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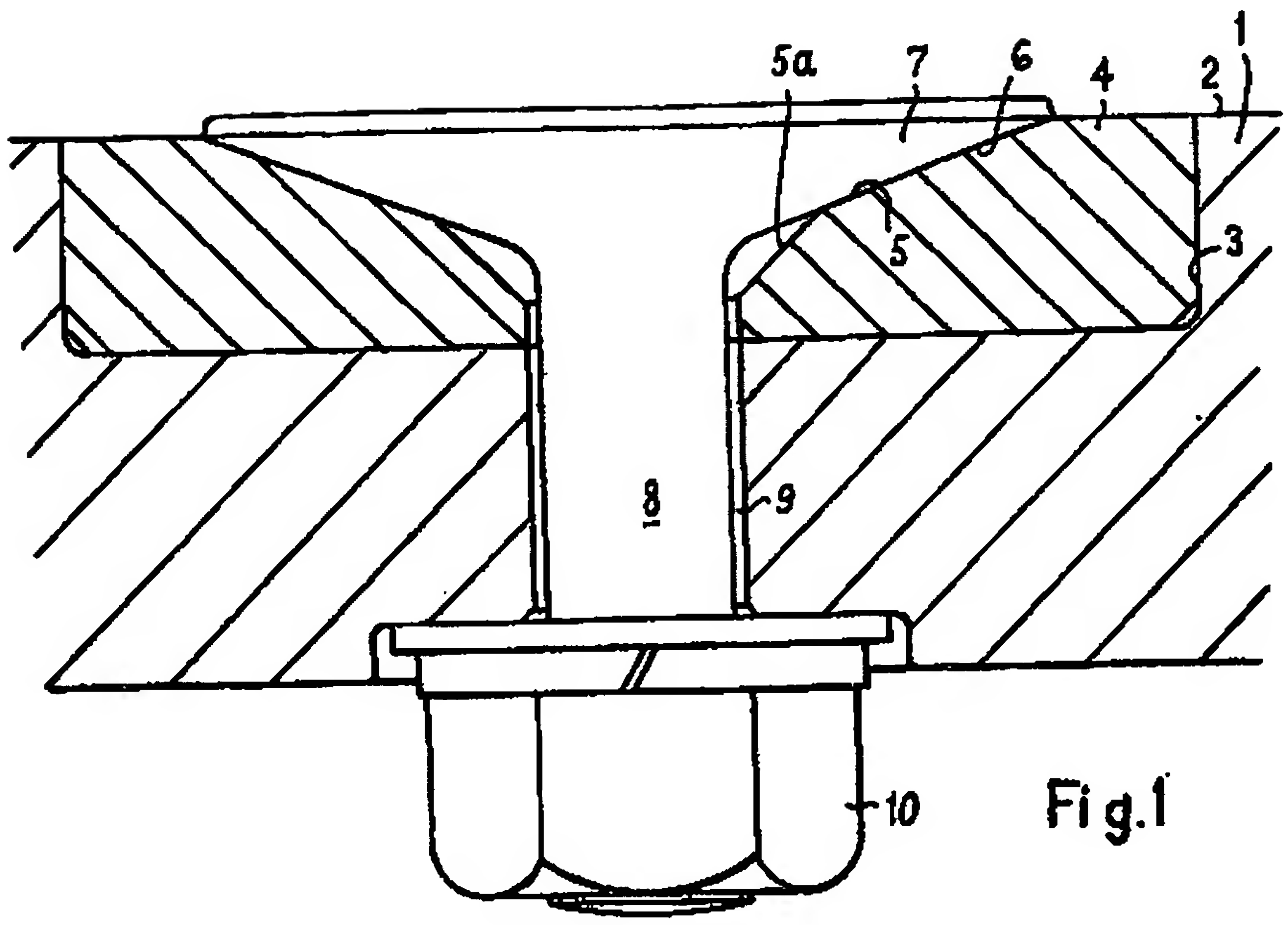

Fig.1

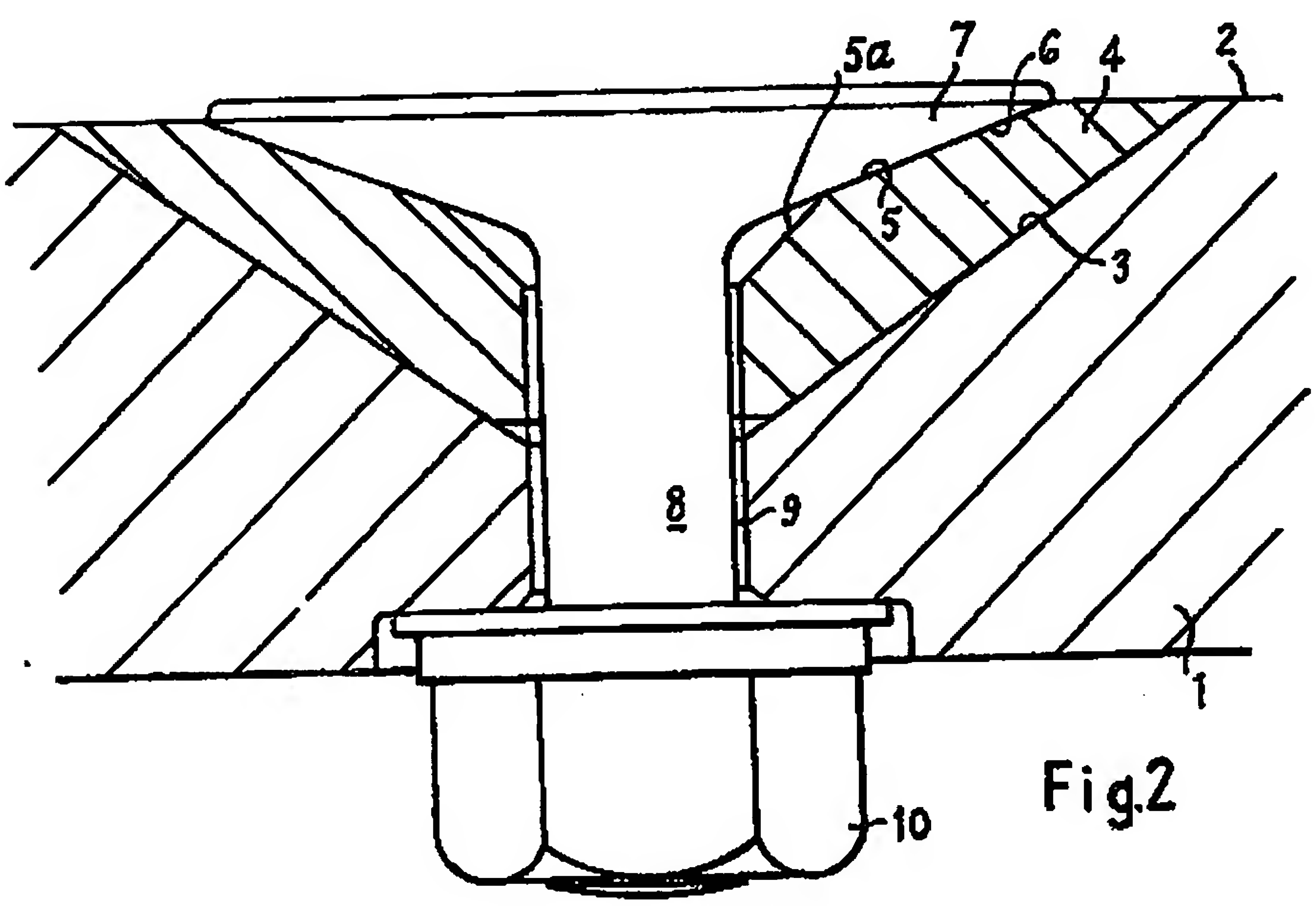

Fig.2

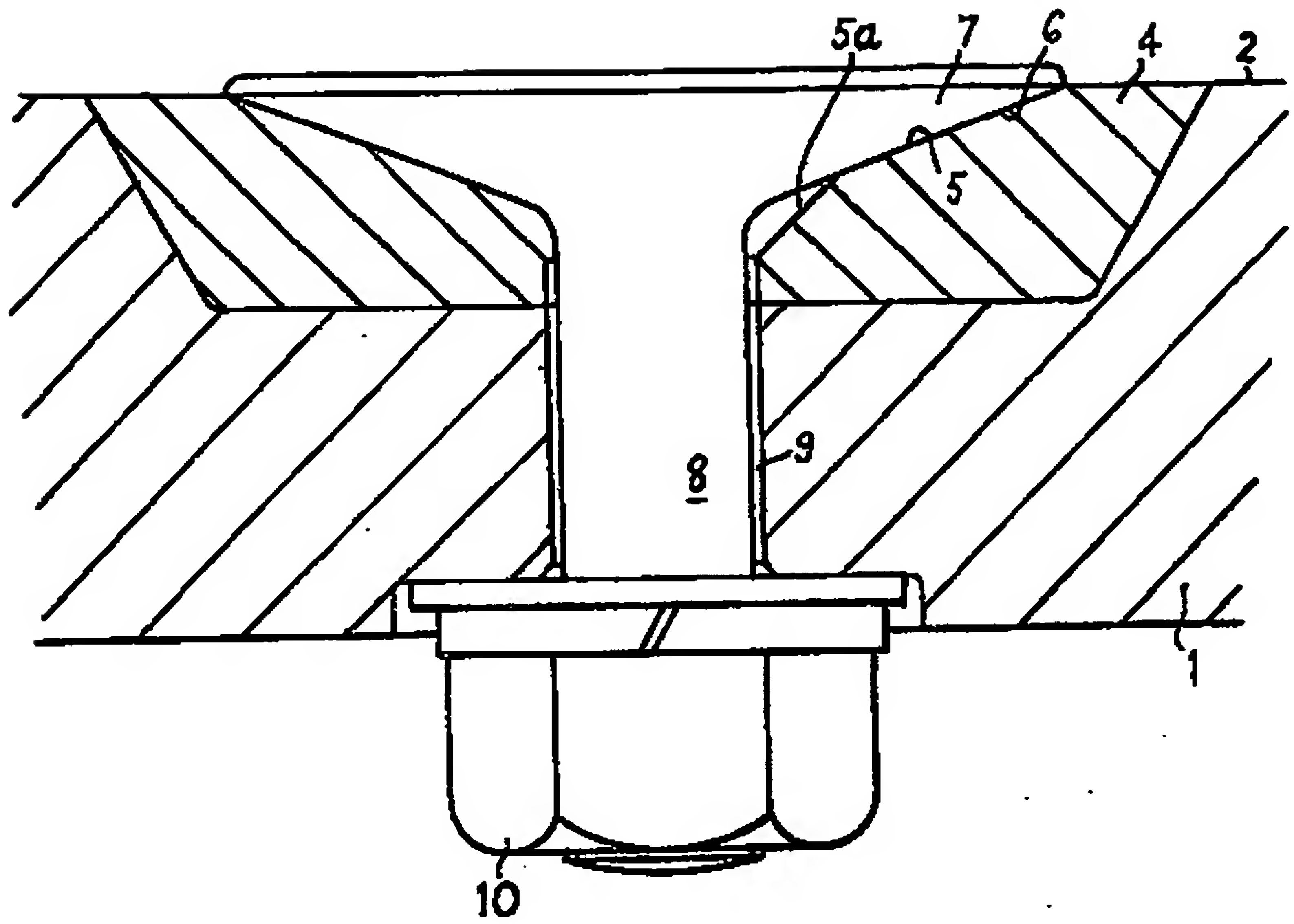

Fig.3